apparently coincides with A_1—the reflection of A in the upper surface of the upper plate; and thus, neglecting for the time light which has undergone more than one reflection, we see this A_1B_4 combination of reflections illuminated by light which has undergone reflection at the two inner surfaces only.

It is clear that if we substitute for the two glass plates the apparatus generally sold for exhibiting Newton's rings, we can by this simple method view the rings by the light proceeding from the two inner surfaces only. Thus viewed, the central dark spot appears of a rich velvety black, and the coloured rings very brilliant. The experiment can easily be projected, and the difference in the appearance of the rings on the screen, with and without the opaque screens, is very striking.

The effect of the two screens can be still more simply given by cutting a slit in a piece of blackened cardboard of about the same width as the thickness of one of the glass plates in the rings apparatus; it is almost needless to state that the cardboard in the region of the upper and lower edges of the slit performs the functions of the screens B and A respectively. In this way the backing of the lower glass plate (to get rid of the reflection from its lower surface) may be avoided; an obvious advantage when it is desirable to show the interference in the transmitted as well as in the reflected light.

But the interest of the method does not only lie in its simplicity. Besides affording an easy proof that the rings are caused by light reflected at the inner surfaces of the plates, it also gives a method of seeing and possibly differentiating the interference curves produced by light which has undergone only one reflection, *i.e.* the rings commonly known as Newton's, from the curves produced by the interferences of waves which have undergone two reflections or more (and these last, so far as I know, can only be shown by this method); for if, using the ring apparatus and a single opaque screen, say 3 inches × $\frac{1}{3}$ inch, we look into the central reflection (A_2) carefully, two sets of rings, intersecting, can be seen. These cannot be due to light reflected at the points whence the rays which form the primary rings are reflected—by what has gone before.

To indicate, without attempting for the present any further analysis, how some of the other interference systems may be rendered visible:—Take a strip of blackened cardboard, say 8 inches × $2\frac{1}{2}$ inches, and view its reflections in the Newton's rings apparatus. C (see Fig. 4) being the lower portion of this new screen, its reflection will be seen to consist of a number of shaded strips, C_1, C_2, C_3, &c.; and in each of these will be evident different interference curves (plainer, of course, when monochromatic light is used); in C_1 the primary rings; in C_2 two series of rings crossed; in C_3 still more complicated forms, and so on; each set fainter than the last, the light to which it is due having undergone more reflections than its predecessor. The method suggested for the experimental analysis of these interference systems can only be sketched roughly here. It is, by the use of a second screen, possibly a third, so to combine the reflections of the screens with observations of the consequent alteration in the interference curves, as to completely verify the results a mathematical analysis of the problem would predict.

T. C. PORTER.

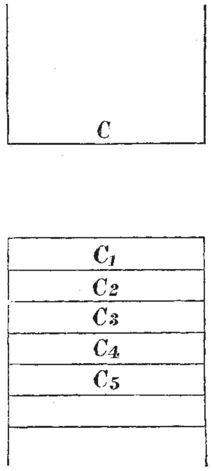

FIG. 4.

JEAN SERVAIS STAS.

FEW, if any, among the men of science of the present day have at once done such important work and earned so little popular recognition as Jean Servais Stas. The names of Faraday, Liebig, Dumas, Darwin, have become household words beyond the laboratory and the lecture theatre, and are frequently taken in vain by the purveyors of "science for the million." But, whether among the "classes" or the "masses," if we mention Stas we are apt to be asked, Who was he? What has he done? If we mention his determination of the atomic weights, we have to follow this statement up with a popular lecture on stöchiometry, and are then told that there is not much in it.

Stas was born at Louvain, on August 21, 1813. Like many young men of scientific tastes in the earlier part of the century, he entered upon the study of medicine, and graduated as M.D. But, feeling himself strongly drawn to chemical research, he came to the conclusion that the life of a practising physician was not his true sphere. So early as 1835 he undertook, in conjunction with his friend De Koninck, an investigation of the root-bark of the apple-tree, and discovered phloridzine, an interesting crystalline body. However, at the outset he merely succeeded in obtaining this body in its pure state and in ascertaining its behaviour with reagents. He decided to go further, and to study the constitution and transformations of phloridzine. To this end he stood in need of further instruction. But the methods of organic investigation were at that time little advanced. The art of research was taught only by Liebig at Giessen, and by Dumas at Paris. Stas made choice of Dumas, and after overcoming endless difficulties, was admitted as a pupil in the laboratory of that distinguished Academician.

Here, he resumed the study of phloridzine, and soon succeeded in determining its formula, and those of its principal derivatives. He ascertained that in contact with acids, phloridzine was split into glucose and phloretin, thus belonging to the class of glucosides, bodies the prototype of which had been discovered by Liebig and Wöhler in amygdaline. Berzelius, a man by no means lavish of praise, declared that "from an investigator who has carried out such a research much may be expected."

Impressed with the ability of his pupil, Dumas requested him to undertake a series of investigations in concert with himself. The first of these researches was the examination of the action of potassa-lime on alcohols. They determined that, without exception, alcohols were transformed into corresponding acids. By their powers methylic alcohol yielded formic acid, and ethylic alcohol yielded acetic acid. Fusel-oil gave a valerianic acid exactly agreeing in its properties with the natural valerianic acid—a discovery of great importance considering the paucity of synthetic organic compounds then known. In conjunction with his master, he ascertained the molecular weight of valerianic acid by a determination of its vapour density and by its conversion into tri- and tetra-chlorvalerianic acid, thus justifying their joint belief as to the alcoholic nature of fusel-oil. This conclusion was experimentally confirmed by the conversion of fusel-oil into valeraldehyde.

Immediately after these experiments, Stas, aided by Dumas, entered on the most important work of his life. It had been already found that on the combustion of the more highly carbonized hydrocarbons the sum of the carbon and hydrogen was decidedly greater than the weight of the substance taken for analysis. Two possible explanations were suggested. The excess might be due to a constant error in the method employed, but on careful and frequent repetition of the experiments no such error could be traced; or there remained the possibility that the composition either of carbon dioxide or that of water had not hitherto been accurately determined. In deciding this question Dumas and Stas developed precautions which had never been equalled, and which certainly have not been since surpassed.

It must be remembered that, like Darwin in another department of science, Stas was his own most acute and formidable critic. He seems never to have wearied in devising possible objections to his methods and results, nor of suggesting loop-holes through which errors might possibly have crept. In redetermining the atomic weight of carbon, graphite (natural and artificial) and diamonds were submitted to combustion in a current of perfectly dry oxygen. After the checking and re-checking of results, the operators were forced to conclude that the true atomic weight of carbon was lower than hitherto had been universally accepted. It had been determined by Berzelius and Dulong as 12·24. Dumas and Stas made it simply 12, and confirmed the result by carefully repeated analyses of many substances of known composition. Hence Dumas was led to accept for the atomic weight of oxygen 16, and for that of nitrogen 14. Whilst Dumas and Boussingault executed their determinations in Paris, Stas carried out the same experiments by the same method at Brussels.

These startling results recalled the attention of chemists to the hypothesis of Prout, *i.e.* that the atomic weights of all the elements must be multiples of that of hydrogen ($H = 1$), by a series of whole numbers. Into this question Dumas and Stas threw themselves heart and soul. The experimenters came to separate conclusions. Stas entered the investigation in the full conviction that he should find the principle of Prout exactly confirmed. At the conclusion of his arduous labours, he found his expectations to be "pure illusion."

On the other hand, Dumas sought to retain the hypothesis in a modified form.

Neither of these eminent researchers seems to have paid sufficient attention to the fact that the atomic weights of a considerable number of the elements differ but very slightly, in excess or in deficiency, from the values which the hypothesis of Prout would require. It is quite possible we are here in presence of a residual phenomenon which interferes with the exactitude of the law.

In a paper recently read by Prof. W. Spring before the Belgian Academy of Sciences the speaker gave an abstract of the unpublished researches of Stas. In a certain memoir, "On Silver," was discussed a treatise by Dumas on the quantity of gases absorbed by silver, in which Dumas had conceived doubts as to the conclusions of Stas on the hypothesis of Prout. For the critical purpose Stas prepared absolutely pure silver, containing not a trace of gases nor of kindred metals. At the melting-point of iridium the silver was volatilized without revealing by the spectroscope any trace of sodium, a metal which Dumas had suggested as being possibly present. This pure silver gave the same atomic weight as the silver used previously by Stas. Hence the atomic weight of silver must retain the value which Stas, in his earliest determinations, had assigned to it, and consequently the objections of Dumas fall to the ground.

A second Stas memoir, recently brought to light, fully investigates the question whether the elements sodium, potassium, lithium, calcium, strontium, barium, and thallium can be mutually transformed either by intense heat or by electric action. To carry out his experiments, undertaken in consequence of the views lately expressed, that the spectra of the above metals assume a different aspect at very high temperatures, Stas required materials chemically, or rather spectroscopically, pure. This difficult task took him eleven years to accomplish. As a result he found that even at the melting-point of iridium (from 2200° to 2500°) the spectral lines of the metals remained unaltered, and that consequently the transmutation of elements under the special circumstance is devoid of foundation. The error may have arisen, as Stas suggests, from the use of materials not absolutely pure.

In this course of experiments he verified the distinction pointed out by Bunsen between the flame spectra and the electric spark spectra of metals. The flame spectrum of sodium, even at the most intense temperature, shows the well-known double yellow line. But in the complete electric spark spectrum there appear six double lines, lying respectively in the orange red, the yellow, the greenish-yellow, the green, the greenish blue, and the violet. In the solar spectrum all these six double lines are represented by black lines. In the spectrum of the electric arc may be recognized the six double lines, but in the intense white light of the poles merely the flame spectrum with its double yellow line.

The results of his investigation Stas describes in a discourse entitled "De la Nature de la Lumière Solaire," delivered in 1891. From the coincidence of the lines of the metals as recognized in the spark-spectrum with Frauenhofer's dark lines in the solar spectrum, Stas inferred that the heat and light of the chromosphere were produced by disruptive discharges.

The daily life of Stas was by no means devoid of troubles. Posts of honour, indeed, were showered upon him both in his own country and abroad. He was Vice-President of the Belgian Sanitary Council, technical assessor of the National Bank, a perpetual member of the Council of Administrators of the University of Brussels, a member of the Statistical Bureau, President of the Belgian Academy of Sciences, Honorary Fellow of the Royal Society (which conferred on him the Davy Medal), Corresponding Member of the French Academy of Sciences, and of the majority of the more distinguished Academies and scientific Societies. So far back as 1873, he was elected an honorary member of the German Chemical Society. He was also a Grand Officer of the Belgian Order of Leopold and of the French Legion of Honour, as well as a knight of many orders throughout Europe.

His earliest remunerative position was that of Professor of Chemistry at the Military School of Brussels, a post he successfully filled for more than a quarter of a century. So paltry was the salary attached to this office that he finally petitioned Government for an increase. His request was granted, but in a fashion worse than refusal. He was voted an additional salary of 200 francs—a sum he naturally disdained to accept. Soon after he suffered from an affection of the larynx, which put an end to the delivery of lectures. He was compelled to tender his resignation, but as he had not completed the thirty years of service extorted by law he missed his pension. From this plight he was rescued by the offer of a post in connection with the Mint (Commissaire des Monnaies). The respite from trouble was brief. A syndicate of speculative capitalists proposed to the Government to coin an enormous sum of francs. With the full concurrence of the Minister of Finance, Stas resolutely resisted a scheme he considered dangerous to the interests of the nation. With a change of Ministry the proposed measure was carried. Stas forthwith resigned his post in the Mint, preferring to sacrifice emolument rather than countenance a step which he knew to be detrimental.

Stas not unfrequently engaged in tasks which appeal more directly to the popular mind than the determination of atomic weights. In 1850, Belgium was thrown into excitement by a poisoning case not less sensational than that of Palmer in our own country. It has been said of Belgium that it is less permissible to knock down an *ouvrier* than to murder a nobleman. A Count Bocarme had poisoned his brother-in-law. Had the crime in question been committed by one of the *people*, it might, if not condoned, have been inquired into in a somewhat perfunctory manner. But as the only man to whom suspicion pointed was an aristocrat, a searching investigation was demanded by an indignant public. The chemical investigation conducted by Stas was performed in a masterly manner. The unerring chemist not only detected nicotine poison, but also the exact quantity which had been administered. The guilt of Count Bocarme was much more satisfactorily established than that of Palmer in the Rugeley case.

With characteristic thoroughness Stas was not satisfied with the mere detection and quantitative determination of nicotine. He elaborated a general method for the recognition of organic poisons in chemico-legal investigations. His method of detection, revised and perfected by Julius Otto, is still in general use among toxicologists, under the name of the Stas-Otto process.

At the London International Exhibition of 1862, to Stas was intrusted the report on the industry of oils and fats. The question was discussed whether the old method of saponification by means of alkalies or the recently invented acid saponification was to be preferred. The experiments of Stas demonstrated not only the superiority of the acid process from an economical point of view, but supplied the industrial world with the working details of a method still followed by the manufacturers of stearine candles.

At the initial meeting of the International Committee of Weights and Measures held at Paris in 1875, Stas appeared as the Belgian representative, and took a very active part in its labours. From 1877 to 1879 he was associated partly with H. Ste. Claire Deville, and partly with C. J. Broch in the selection of the metals to be used as standards or prototypes for weights and measures. The alloy selected consisted of 90 per cent. of platinum, and 10 per cent. of iridium. The reports are rich in important observations on the properties of the platinum metals. Unfortunately they have been published, so far as the writer is aware, only in the *Procès-Verbaux du Comité International des Poids et Mesures*, documents not readily accessible. The results have still to find their way into the text-books and metallurgical manuals.

But other labours of the illustrious Belgian chemist have still to be unearthed. At the request of his Government he carried out important researches on metallic alloys for the manufacture of heavy artillery. His copious reports are said to be buried in the archives of the Belgian War Department.

In one quarter only did Stas encounter ill will. He was a champion of the freedom of research and of the independence of the Universities. Hence he came into frequent collision with the "clerical party," which in Belgium plays a *rôle* similar to that of the ethicists and self-constituted "anti-" Societies in Britain.

On January 1, 1891, at the King's New Year reception he courageously reminded the Ministry of the respect which a Government owes to science. We regret we have not met with the text of this discourse, which would be worth reproduction in England. The insulting replies to the bold utterance of Stas were drowned in the loud and general approval of the country.

It is pleasant to add that the personal character of Stas was in harmony with his scientific pre-eminence. He was a man of whom it could be said, "Nihil tetigit quod non ornavit." It was one of his great distinctions that, unlike many illustrious men of science, he was not followed to the grave by the ghosts of dead theories.

NOTES.

MEN of science were glad to see that the list of those on whom birthday honours were conferred included Dr. John Evans, who has become a K.C.B.; Mr. W. T. Thiselton Dyer, who has been made a C.I.E.; and Mr. H. H. Howorth, who has been made a K.C.I.E.

THE annual visitation of the Royal Observatory at Greenwich will take place on Saturday, June 4.

THE Secretary of the British Association Committee for arranging for the occupation of a table at the laboratory of the Marine Biological Association, at Plymouth, requests us to announce that applications for the use of the table during the present summer should be addressed to him (Mr. S. F. Harmer, King's College, Cambridge) not later than Friday, June 10.

MR. WALTER GARSTANG, M.A., Berkeley Fellow of the Owens College, Manchester, and formerly assistant to the Director of the Marine Biological Association, has been appointed to a naturalist's post upon the staff of the Marine Biological Association at Plymouth, and will have charge of the dredging and collecting operations conducted at the station.

IN the fifth Annual Report of the Liverpool Marine Biology Committee (December 1891), Prof. Herdman suggested that the marine biological station might with advantage be changed from Puffin Island to some more easily accessible part of the district, where a fresh area could be investigated. After a careful consideration of several sites, the Committee decided upon Port Erin, at the south end of the Isle of Man, and a suitable building for a marine laboratory, of three rooms, has now been erected, on the beach immediately below the Bellevue Hotel, from plans prepared by Prof. Herdman. This laboratory being ready for workers, and a number of members of the Liverpool Biological and other scientific societies, and also of the Isle of Man Natural History and Antiquarian Society, having expressed an interest in the progress of the undertaking, the Committee have resolved to inaugurate the station by a formal opening on Saturday, June 4. The Lieutenant-Governor of the Island, Mr. Spencer Walpole, has consented to perform the ceremony; and His Excellency, and the Bishop of Sodor and Man, have accepted the invitation of the Committee to be present at a luncheon to be given at the Bellevue Hotel on the occasion.

THE Puffin Island Biological Station has been taken over by several members of the staff of the University College of North Wales, Bangor, and will be worked henceforth in connection with that College. Dr. Philip White, the lecturer on zoology, has been appointed director of the station. The island is in full view of, and within easy reach of, the College. The station, as formerly, will be entirely supported by voluntary contributions.

THE Marine Biological Laboratory at Wood's Holl, Massachusetts, will be open for investigators from June 1 to August 30. The demand for tables at the laboratory has been so great